TM-650
2100.000

A CURRENT-LIMITING TECHNIQUE FOR WIRE CHAMBERS

C. R. Kerns
March 26, 1976

Introduction

The designers of wire chambers are generally faced with the problem of how much series resistance to place within their chambers between the incoming power supply voltage source and the wires. Although Fig. 1 is an oversimplification of a chamber system, it represents the usual construction practice and will serve to illustrate the problem.

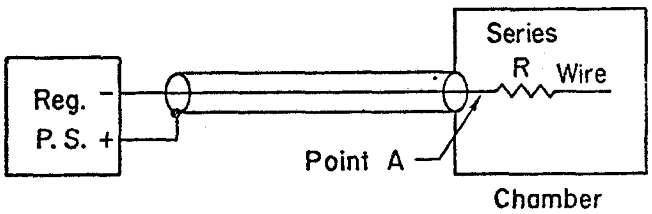

Fig. 1

For efficient normal operation of the chamber, one would prefer that the series R be fairly small so that good voltage regulation is maintained at the chamber wires over a reasonable working range of counting rates and the ensuing average chamber current variation.

On the other hand during abnormal operation, such as sparking or other damaging discharges, the chamber designer would desire a large series R to "soften" the voltage source.

In what follows there is a description of how to apply the principle of fold-back current limiting to chambers. The virtue of fold-back current limiting is that the chamber voltage is maintained constant from zero current up to some set current limit, such as 100 microamps; beyond the set limit the chamber voltage falls very steeply with increasing current.

This note will also describe supplementary circuitry which provides a fast crowbar at the set current. Using both these ideas in conjunction with each other, it is practical to minimize both the stored energy term $1/2\ CV^2$ and the follow-through energy from the power supply, $\int IV\,dt$.

Application of Fold-Back Principle

Figure 2 shows circuitry that has been added at point A between the cable and the chamber.

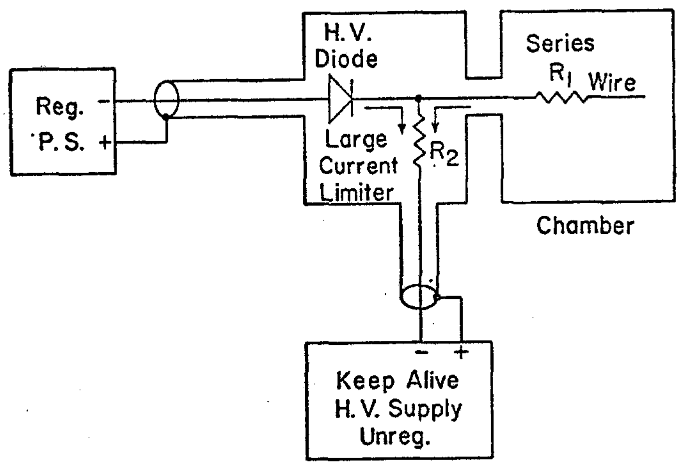

Fig.2

Comparing Figs. 1 and 2 one soon notices the addition of three components: the Keep-Alive HV supply, a large current limiting resistance, and a HV diode. During normal chamber operation, the Keep-Alive supply provides, via the large R, a substantially constant current (i.e., 100 μAmps) which at the junction of the diode and chamber wire "splits" and flows two ways.* Depending on the count rate of the chamber, some fraction of the total constant current is provided by the chamber with the remainder provided for by the diode leg. Supposing the keep-alive current to have been chosen as 100 μAmps, then for any chamber current from zero to 100 μAmps, the diode is turned "on", and the chamber voltage is constant. For any additional current δ above 100 μAmps, the chamber voltage falls with increasing current at the rate of $\delta \times R_2$. Figure 3 shows the voltage regulation under load.

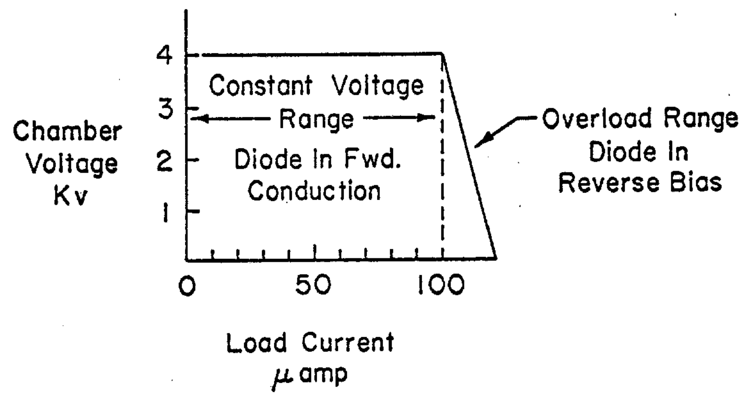

Fig. 3

The overload range can be made to fall as steeply as required, just be making R_2 extremely large, or, by in fact making it a (non-linear) constant-current device. The effort of making R_2 a constant-current device would probably not be worth it -- a linear resistor, much cheaper, works well enough. Also,

---

*As you see, I draw the arrows representing current the way Ben Franklin suggested, so there is shown a confluence of two currents at the junction. If you prefer G. Johnstone Stoney, change the direction of the arrows but the concept is the same.

demanding an extremely large R_2, or a constant-current R_2, makes the keep-alive supply more expensive and involves extra-high voltages.

It appears that one can do well enough with a quite simple system, and that is what I will describe.

Practical Implementation of Fold-Back Protection

Figure 4 shows a practical implementation for several chambers simultaneously connected. Each chamber retains the ability to have its supply voltage independently and remotely adjusted for optimum operation.

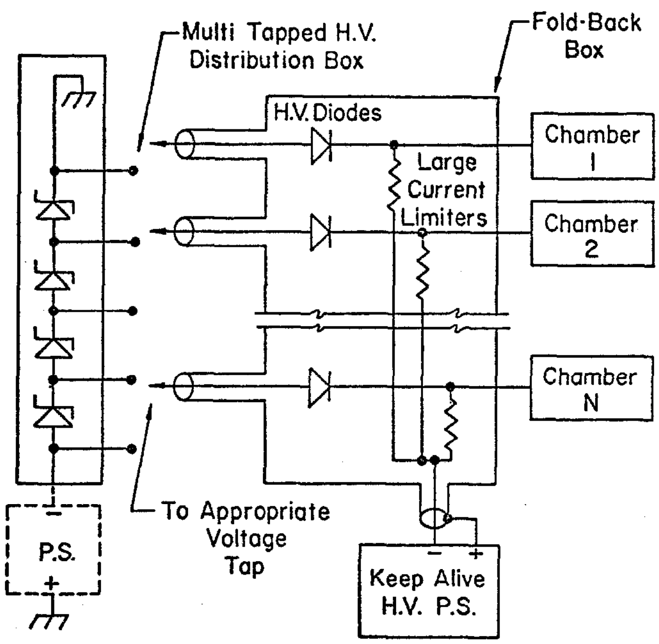

Fig. 4

Some interesting ramifications follow from this overall arrangement:

1) The regulated power supply doesn't supply power; in this configuration it absorbs power, and could even be a passive string of zeners.

2) The capacitance of the cable doesn't discharge into the chamber in case

of a spark -- instead, the HV diode disconnects the cable. Only that capacitance to the right of the diode "dumps" into the spark. See Fig. 2.

3) The Keep-Alive supply can be inexpensive and unregulated. It provides current, but doesn't determine the chamber voltage.

4) The extra components are physically small enough to be incorporated into the chamber, should it be required to cut the stray capacitance to a minimum in order to minimize the energy delivered to a spark by the 1/2 CV^2 term.

Fast Crowbar

The evolution of the fold-back current limiting circuitry suggests an ideal addition: make the current go to zero in case of fold-back. Recalling that the power supply energy delivered is the integral of volt-amp-seconds, the quicker one removes the energy source the less likely is wire damage. With this in mind, a fast crowbar (CB) has been developed for addition to the Fig. 4 fold-back box. Figure 5 illustrates the CB fold-back box as it is now configured for E290.

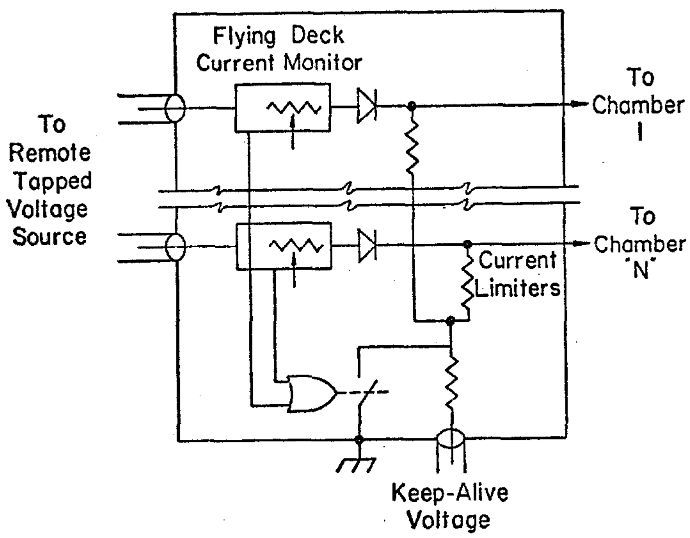

Fig. 5

The current detector (floating at HV) notices if the diode current drops to zero; if so, it triggers the crowbar which shuts off the Keep-Alive supply. A single Keep-Alive supply can feed a number of chambers and diodes, but an individual current monitor is needed for each chamber.

High Voltage Diodes

A note concerning the HV diodes is in order. There are several manufacturers of HV diodes (see below), however not all HV diodes are necessarily good choices for this application. During selection, one should investigate the dV/dt they can withstand as they are rapidly switched in the back bias direction. A reasonable approach (but bulky) for obtaining HV diodes is to suitably series LV diodes. I know this works because that is how I built the prototype.

HV Diode Vendors

1) Varo Semiconductor, Inc.
2) Rectifier Components Corp.
3) Solid State Devices, Inc.
4) International Rectifier Corp.
5) RCA